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G. MOURET, *Le Problème d'Achille*. Revue Phil. Jan. 1892.

According to Mouret, Zeno is guilty of a "*petitio principii*," because he seeks an unknown quantity which his very method excludes. The error permitted in dealing with convergent series should have been rectified by passing on to the limit, which in this case is zero, and consequently implies a position common to the tortoise and his pursuer. This correction once made, it is clearly possible for Achilles to overtake the tortoise; whether he actually does so is a question that depends not on the relative, but on the absolute, velocities. If these do not approach zero, Achilles will succeed within a determined time; if they do approach zero, he will never succeed, but his failure implies nothing at variance with the concept of motion.

EPSTEIN, *Die logischen Principien der Zeitmessung*. Inaug. Diss., Leipzig, 1887.

On the side of empiricism, Newton distinguished between absolute and relative time. The absolute or mathematical time has a uniform flow; the relative time, measured by cosmic or artificial motion, is subject to irregularities because the motions vary. Absolute time, like absolute space, matter, and motion, are not abstractions needing justification, but the *veræ causæ* of the corresponding relative facts. None of our measurements correspond to the actual or absolute qualities. The error takes different directions for time and space. We cannot perceive empty space, only space as occupied by bodies. If these were at rest space could be mapped out with accuracy; but since they are probably in constant motion, the point from which we measure is liable to change. Motion is the only measure of duration; if it were uniform, it would measure absolute time; but no uniform motion is known, so in the case of time our unit of measure is liable to variations.

On the psychological side Locke came to a similar conclusion. A notion of time is gained from the succession of ideas. From periodic sensations we derive a unit of measure, which we extend to all phenomena in which such a unit is absent. Not simply motion, but all periodic phenomena furnish a unit of time. The difficulty with time measurements is that we know no uniform motion or regular periodic process. The year, the day, the swings of the pendulum—all vary. A second difficulty peculiar to time is that one stretch of time cannot be superposed upon another, while this method of superposition is the foundation of space measurement. The author shows that this class of objections, though of special force in regard to time measurement, applies to the measurement of any two different parts of the same continuum, whether time, space or motion.

To apply geometry practically we pass from the absolute to the relative space by two axioms, which may be united as follows: A body under the same conditions, at different places, or at different times, occupies equal spaces. Practical time measurement is founded on a similar axiom. An event under the same conditions at different times or at different places has the same duration. The empirical and naïve psychological theorists considered time a substantial thing whose nature was to be investigated, and found discrepancies between the absolute and relative or practical time measurements. The author treats the problem from the point of view of the theory of knowledge. Time is not to be considered a substance, but as a category introduced by us into the phenomenal world to give order to events. The phenomenal world is united into a whole by the causal category; any given value of it determines the next. Time is an independent auxiliary variable introduced to fix any given stage or value of this phenomenal world, and to enable us to pass connectedly from one value to another. It is the

means of a systematic view of natural processes. The question what is time, or what are equal times, is a matter of definition. Equal times are those in which identical events take place. Time is concerned only with events, and we know nothing of empty time. There is no criterion of identical events independent of time, and we must be content with assuming that two events are identical when it is more reasonable to assume that than the contrary. The paper closes with a criticism of the recent mathematico-physical definitions of equal times.

#### TOUCH, PAIN, INTERNAL SENSATIONS.

GOLDSCHIEDER. *Ueber die Summation von Hautreizen*, Dubois-Reymond's Archiv 1891, 164.

Lightly stimulate the skin with the point of a pin, or even a somewhat blunter instrument. A pricking sensation arises, dies away, and is succeeded by a secondary, or after-sensation, which also has the prickly feeling, but lacks the touch-tone which marked the primary one. It seems very much more as if it came from within. If the stimulus be stronger, but at the same time not quite strong enough to make the primary sensation painful, the secondary sensation will be felt as painful. But if the strength of the stimulus be still further increased so as to give the painful tone to the primary sensation, then the secondary is feebler than the primary, and does not flash out as clearly, since the interval between the two is partly filled by the persistence of the primary sensation. Goldscheider found that a single electric shock in no case gave rise to this secondary sensation. In order that it should arise it was necessary to make a number of such stimuli, one after another, on the same spot. This gave a clue to the explanation of the above phenomenon, and also suggested lines of experiment. He and Herr Gud sought to determine under what conditions a series of stimuli is competent to produce the secondary sensation,—how long the series must last, what the interval should be between the shocks, and what the intensity of the current. A series of four gives a clear secondary sensation, but only with certain intervals between the stimuli. With an interval of from 0.03 to 0.06 second, the sensation is most clear. As the interval is made smaller than the former number, or larger than the latter, the secondary sensation becomes less and less clear, finally disappearing altogether. The like is true if the number of stimuli in the series be increased. For each number a certain range of interval is found which gives the secondary sensation the maximum of distinctness. This interval varies, however, inversely with the number of the stimuli. The product of number by interval is found to be (nearly) constant.

In each case a certain intensity is found best fitted to give the secondary sensation. Increasing or diminishing the intensity beyond this point enfeebles the effect. The time elapsing from the end of the series to the rise of the secondary sensation was measured and found to be (on the hand) about  $\frac{1}{10}$  second. Increasing the duration of the series by increasing either the number of stimuli or the interval between them has no appreciable effect on this time, until the point is reached when the number of stimuli given is just the number necessary (with each particular interval) to bring out clearly the secondary sensation. If we increase the number beyond this point, the secondary sensation comes out independently of the duration of the series, but with its same time-interval. That is, increasing the duration of the series beyond this point, the interval between the end of the series and the rise of the secondary sensation is correspondingly shortened. When the series is made to last about  $\frac{1}{10}$  sec., the secondary sensation flows into the primary, or does not arise at all. Similar results are found with